thing more than doubtful. The absence of such an anal plate in the ancient Cidaridæ, the mode by which the anal plates appear in *Echinocidaris*, the membranous condition which obtains in *Diadema* (a form ancient enough, as we now know, to retain a rudimentary internal gill), suggest that what is seen in the more highly differentiated Temnopleuridæ is due to some secondary process now considerably obscured. It is possible that an increase in the rapidity of the rate of development has here, as sometimes happens with the blastopore and the mouth or anus, given to a more lately acquired structure a superficial resemblance to one which was not even its proper predecessor.

On a Lithistid Sponge and on a Form of *Aphrocallistes* from the Deep Sea off the Coast of Spain. By Prof. P. Martin Duncan, M.B. Lond., F.R.S., F.L.S., &c.

[Read February 17, 1881.]

(Plates XXIV. & XXV.)

During one of the dredgings of the Expedition of H.M.S. 'Porcupine,' in 1095 fathoms, off the south-west coast of Spain, a mass of fistulose coral was brought up; it included in its branches many foreign substances, and amongst them two small siliceous sponges. The coral was described by me in my monograph of the deep-sea corals*; and lately my attention has been drawn to the beautiful sponges.

One of them, about an inch in height and one third of an inch in thickness, has numerous oscules on it, and it is perfect in its hard parts. Of the soft tissues no idea can be obtained. The sponge evidently belongs to the Lithistidæ; for the skeletal elements branch after the fashion of the group, interlock at their ends with more or less filigreed terminations, producing a continuous network, and there are connective peltate spicula on the outside.

The sponge-body is very hard and resisting; but it is smooth to the touch and eye, and is of a dirty white colour; the outside of the body is faintly wrinkled here and there, and is produced on the flanks and at the apex into several wart-like elevations, each terminating in an oscule which leads deeply into the mass. The oscular processes are short, unequal, differently directed, and

* Trans. Zool. Soc. vol. viii. pt. v. p. 327.

have their bases sloping gradually on to the body. The oscular openings are unequal in size, are crateriform, and their wall is evidently stout. (Plate XXIV. fig. 1.)

A transverse section of the body reveals a thin dense cortical part, enclosing a lax sponge-like internal structure, with cavities and canals of different sizes; and these end externally in the oscular projections. (Plate XXIV. fig. 2.)

The cortical part exhibits a totally different structure to that within, and is dense and close; it forms the outside of the body and of the oscular processes. No pores are visible on the outside of the body with the naked eye; but the microscope reveals minute spaces between the margins of the foliato-expando-ternate spicula of the derm. Water enters very readily through the dense cortex into the interior.

A section through the sponge-body, made sufficiently thin to be used under transmitted light, without disturbing the position of the structural elements, revealed the histology; and a thin slice made parallel with the surface enabled its details to be satisfactorily described and figured.

The transverse section shows the dark line of the dense but thin cortex on the outside, and within it concentric layers of spicula grouped in different manners, the outer layer being connected with the connective spicula of the cortex by means of short, stout, cylindrical processes. No free stems project inwards from the foliated edged peltate-looking, connective spicula just noticed; for the stems are invariably attached to the proper spicula of the body just within. These outer proper spicula of the body are in very close order, and within them is a series of radial spicula massed into radial columns with spaces between them, giving the appearance of rather a lax tissue. The columns impinge, internally, on a thick concentric layer of shorter spicula much confused; and this is attached within to a columnar layer like that external to it. This alternation of close and open concentric layers is repeated several times with more or less regularity.

The result of this arrangement and grouping of spicula is to develope a series of moderately sized spaces in concentric series, and to establish a less permeable set of layers between them. Here and there the spaces become larger, and in some places small *cul-de-sacs* or tubes are formed; but it is done at the expense of the concentric close layers which abort; and the long

spicula are then either doubled in number or are greatly enlarged radially. Some have the limbs by which they usually unite to the shorter spicula of the concentric layers greatly enlarged and curved, so as to include more or less of the side of a tube (Plate XXIV. fig. 3). Near the larger canals in the interior, the concentric and radial arrangements are lost, and a confused tissue, consisting of medium-sized spicula uniting by very spinulose and ragged ends, exists. The bunched masses of spicular endings give an opacity which is very difficult to overcome (Plate XXIV. figs. 4–7). In portions of the section, the columns are so thick as to render the distinction into concentric and radial parts uncertain.

The spicula of the interior of the body vary much in size, and are, as a rule, beautifully transparent. The trifid outline prevails, and the fourth limb usually exists, but sometimes it does not, or is invisible.

Curved limbs ending in ragged, semi-spinose, or flat processes are common; but this raggedness is not long or in excess. It is often toned down into a series of short blunt projections, which are rather opaque and reflect light strongly.

In the columns, one limb of the spicule is always greatly developed, being long and narrowest centrally; and the other limbs are small, being sometimes indistinguishable from the irregular junction part.

The articular processes at the ends of the limbs are excessively irregular in shape, not very close, and rather short as a rule. Projections occur on all sides of the ending limbs; but they are rare on the main one (Plate XXIV. fig. 3), where isolated spinules are not uncommon. The spicula which join on to the ends of these radial ones are more compact, and their limbs are more equal; they are smaller than the others, and some are minute, forming an excessively close areolation. In the first instance the curvatures of the spicula are very decided, and the ends of the limbs are ragged (Plate XXIV. fig. 4); their surface is sparsely ornamented with dot-like projections, circular in outline. In the second case, the minute spicula run into each other at the limb-ends, with or without ragged projections; and the various angles of junction produce an incoherent arrangement (Plate XXIV. figs. 4–6).

These smaller spicula are trifid and quadrifid. Where separable, they present fractures and nodular points at the edge of the

arms (Plate XXIV. fig. 6) and little fixed spinules on the edge of the limbs. The spaces produced by the junction of these spicula are very small, and are intruded upon by the ornamentation as well as, to a certain extent, by the spicular arrangement of the limb-end. This more or less close structure is increased by the presence of minute acute-pointed spicula seated on the limb-ends (Plate XXIV. fig. 7); those of approximate limb-ends interlock. In many instances the junction is by simple contact of smooth surfaces, without the intervention of this minute spinulose element, or by flattened-out disks and ragged ends. Throughout, the peculiarity of the spicula is their general plainness and their scanty ornamentation of projecting spinules, sharp or blunt-headed.

The bases of the large spicula of the columns merge into or join, by ragged junction, short, stout, and irregularly shaped spicula, with a limb curved outwards towards the periphery (Plate XXIV. fig. 8). These last form the groundwork of the cortex, and they are crowded, the spaces formed by their junctions being very small. Their curved outer limb is covered with short and thick projections, more or less cylindrical and expanding outwards, where they are often ragged (Plate XXIV. fig. 8). These processes form a layer just within the outside of the cortex; and as they are close and their interspaces are excessively small, there is an approach to solidity.

The last kind of spicule to be noticed (Plate XXIV. fig. 9) forms the outside of the sponge, and consists of a very short base, which is narrow and more or less circular in transverse outline, and a widely expanded part perpendicular to the base and placed with its baseless face outwards. The expanded parts of these peltate spicula produce the smooth glistening surface of the sponge. Their shape is, moreover, very remarkable. An original trifid arrangement can sometimes be traced, and the stumpy cylindrical stem is the fourth limb; but each of the tripartite portions is broken up into a series of very ragged, deeply incised, dendritic-looking processes. These branch and rebranch, and terminate in minute ramuscules, ending often in minute sharp points arranged in a most ragged and eccentric manner. The ramifications give a dendritic appearance to these connective spicula, and, to a certain extent, they interlock with those of their neighbours. The spaces left between the ramifications are small and microscopic and act as pores. The absence of free stems to these foliato-expando-ternates has been already noticed, and hence the sponge is rigid.

No flesh-spicules exist on the outside of the cortex, and there is not a trace of any within. A few *Globigerinæ* and two or three long and small attenuate spicula were detected; but they evidently are foreign bodies, one spicule exhibiting the results of decay.

The specimen is characterized by its cylindrical shape and external oscular processes, its smooth and glistening surface, its dense derm of connective foliato-expando-ternate spicula highly dendritic at the edges, its close outer body-spicula with their cylindrical processes of attachment for the connective spicula of the derm, its alternating open and close main structure, with the highly spinulate nature of the quadrifid or tetraclade spicula, and by its deficiency of free stems to the connective spicula, and of all acerates and acuates and other minute sarcodic forms.

The form is evidently a Lithistid amongst the Siliceo-fibrous Spongida; and it is indistinctly tetraclade. Amongst the known species of Lithistids with surface-spicula with dendritic edges are *MacAndrewia azorica*, Gray, which probably is the same thing as *Corallistes clavatella*, Schmidt, and *Kaliapsis cidaris*, Bow.

The new form is neither of these, which, moreover, have flesh-spicula acerate, fusiform, curved, and microspined. I do not wish to establish a new genus from the main characters of this interesting Sponge, and propose to defer the consideration of its classificatory position for a time. Certainly the fixity of the connective derm-spicula is very remarkable. Bowerbank very properly insisted upon the great importance of the free end of the peltate spicula in the growth and swelling out of the sponge; it enabled the cortex to separate more or less from the body. But in this form every part was rigid; and in order to grow, the whole of the derm-spicula must have become deciduous. Lately Carter has expressed his belief that the derm-spicula become skeleton forms during growth; but it does not appear possible in this instance.

The second specimen of Sponge is cup-shaped, with a narrow, cylindrical, short base expanding below into a ragged foot. It is about half an inch in height, and is composed of one layer of network of continuous siliceous spicules. The spaces are large, and the solid part is broken up into minor spaces. Outside are the relics of a derm crowded with derm-spicula. The form clearly belongs to the genus *Aphrocallistes*, Wright. (Perceval Wright,

Aphrocallistes Bocagei, Q. J. Micr. Sci. 1870, p. 4. Fistulous branching sponge.)

Carter, enlarging on the diagnosis, gives a careful description of the species (Quart. Journ. Micr. Sci. vol. xii. p. 450). He notices that, besides the common large sexradiate spicula on which the vitreous structure is based, there are several other kinds, all of which are more or less free from the vitreous mass. Of these, the brush-spicule, and the rosette with three rays to each arm, are common in the specimen under consideration, and the scopuline spicula also.

The form under consideration is a young one and not a fractured old one. At one spot on the free edge the process of mesh-making can be well seen to be due, both to the collection of silica around previously existing hexactinellid or quinqueradiate spicula, and also to the growth of irregular siliceous threads in the sarcode, irrespectively of any geometrical form. The dermal spicula differ in many points from those which have been published as characteristic of *Aphrocallistes*, but some of the normal kinds are present.

Derm.—Very slender, long-rayed, hexactinellid spicula. The stem is as slender as the rays, but is shorter and straight. The rays are very slender, uniform in thickness, slightly bent, and long. At the junction is a slight swelling, and the prolongation of the axis is short and rounded off in a blunt spear-point. Sarcode adheres to the spicula, and extends between the rays.

The arms are separate from those of neighbouring spicula, or are under them, forming a discontinuous network (Plate XXV. fig. 2). These spicula are very numerous, and are found crowding the outside of the main skeleton and the derm which covered up the interstices. Often the vertical limb stands on the siliceous continuous skeleton, and the four at right angles to it then extend on all sides.

Slender, moderately long-rayed, hexactinellid spicula—the axial ray very long, above and below the plane of the others, in one direction slightly curved, and jagged on the edge (Plate XXV. fig. 3). Small hexactinellid spicula—the axis on one side of the plane of the radii, minutely ascendingly spinulose (Plate XXV. fig. 7). Others with the spinules standing out at right angles to the axial ray, and very minutely rugose about the rays also (Plate XXV. figs. 4 and 5). Moderate-sized hexactinellids—the radii stout and attenuating, and one of the axial rays also; the others slightly shorter, and closely but sparely spinulate in whorls,

the spinules being rather long and curved, the points looking obliquely from the stem. This brush-shaped form lies with the brush on the derm and not projecting (Plate XXV. fig. 8).

Hexactinellid spicula—the four rays minutely serrate and spined, not quite straight; the lower part of the basal ray rather short and attenuate, and the upper shorter, but ending in a collar around a knob; both hirsute, with minute very short spinules (Plate XXV. fig. 13).

Small, short-rayed, minutely spinulose or serrate, hexactinellid spicula (Plate XXV. fig. 14). Short, stout-rayed, hexactinellid spicula, with a long, fusiform, axial fibre (Plate XXV. fig. 15).

There are also three small kinds of the ordinary quinqueradiate type, the axis being prolonged as a sixth ray into a small knob; their size varies, and they form a discontinuous network within the larger forms; and many are in contact with the reticulate skeleton.

Spinulo-recurvo-polydentate spicula of exquisite delicacy. The spinule is long, swollen near the head, and narrowed off at the further end. The watchglass-shaped head has a fringe of numerous, recurvate, long and slender processes of great tenuity; they resemble the prolongations of the rosette of *Rhabdodictyon delicatum*, Schmidt. They are in the derm, and appear to stand out from it. (Plate XXV. fig. 5.)

Very small, multiradiate, burr-shaped rosettes. The short, very linear nine or ten radii, arising from a common centre, end in slight club-shaped knobs, rather thickest where they spring from the radii, and bluntly spear-shaped at the end. The whole is situate at the extremity of a long needle-shaped spiculum, which runs into the sarcode. Some of these approach the "spinulo-multifurcate sexradiate stellate" spicula of Bowerbank; but the sexradiate intermediate part is rather indistinct. They are numerous in the derm. Others are "spinulo-trifurcate" (Plate XXV. fig. 11) and "spinulo-bifurcate" (Plate XXV. fig. 12). Minute sexradiates, one limb very small; all the rest trifurcate at their ends (Plate XXV. fig. 9). Larger forms, the axis being a long fusiform ray extending on both sides of the plane of the four rays, each of which is very small, and two are terminated by a trifid extremity (Plate XXV. fig. 10).

The projections from the thick continuous skeleton-fibres are:—(1) stout at their origin, and sloping down to a fine spicule-shaped process of various lengths; (2) stout at their origin, and rather

suddenly diminishing, and then being prolonged in a fine cylindrical spine (Plate XXV. fig. 17); (3) very fine cylindrical spines, as slender as the long attenuate spicula, lying on the skeleton, and long enough to cross a space between the meshes; (4) short, cylindrical, slender-stemmed, club-topped, spinulose projections, and some of greater length (Plate XXV. fig. 18). At the base of the body, however, the reticulation is of a very different character to that seen elsewhere; it is smaller, closer, and consists of a vast number of hexactinellid spicules turned into skeletal tissue by exogenous increase of silica. The arrangement is continuous; but there are no wide interspaces. Long spicula are seen here and there, cylindrical and attenuate.

At the free growing edge, the skeleton of the body is in a most rudimentary state; and it is evident that two sets of spicula are forming the lattice-work—hexactinellids and quinqueradiates. But there is a very irregular broken net-looking mesh of siliceous fibres, in which the shape of the ordinary spicule is not traced. This irregular structure covers much space, has a derm on it in some places; and it appears to have been produced by the sarcode, and not through the intervention of joining spicula (Plate XXV. fig. 19).

Here and there long, very tapering, attenuate spicula, more or less closely spinuled, or rather serrated, are in contact with the skeleton of the meshes (Plate XXV. fig. 16); and they are in contact with others which are not spinuled; and both sets overlap, and form a structure between the derm and the skeleton.

The meshes of the body-skeleton are moderately uniform in thickness in some parts, and the spaces between the interspaces are wide, on the whole, in the stem of the sponge. The skeleton of the mesh is very reticulate, and unequal in size, and usually the surface of the large continuous spicula is granular. The spiniform projections are numerous, and many cross nearly or quite over an interspace. The resemblance of the skeleton to that of *Aphrocallistes Bocagei*, Wright, is considerable in some parts; but it is interesting to note the structure of the base and the variety of the spicule elements, as affording distinctions of more or less value.

Oscar Schmidt, in his 'Spongien der Meerbusen von Mexico' (Jena, 1880), names a form which is by no means unlike that now under consideration in shape; but even the very short

and insufficient diagnosis of *Cyathella lutea* suffices to distinguish one from the other (Schmidt, *op. cit.* p. 46, Taf. vii. fig. 2).

A still greater resemblance in shape exists between the new form and *Rhabdodictyon delicatum*, Schmidt (*op. cit.* p. 46, Taf. vii. fig. 3); but the beautiful rosette of this very lax-meshed Mexican-sea species is not distinctive. The rest of Schmidt's diagnosis is insufficient to establish a species.

On the seventh plate of the same work, Schmidt gives some figures of *Aphrocallistes Bocagei*; and one is interesting (fig. 5 B), for it indicates a young specimen with its base. It is, as far as its lower third is concerned, very much of the size, and resembles in shape, the new form; but there are no indications of the peculiar basal structure just described.

Finally, there are some points of resemblance, but not sufficient to necessitate a generic alliance, with *Aulodictyon*, S. Kent.

DESCRIPTION OF THE PLATES.

Plate XXIV.

The Lithistid sponge.

Fig. 1. The body, natural size.
2. A transverse section, natural size.
2 *a*. The same, magnified.
3. Large column-spicula of the radial open structure, magnified.
4. A spicule of the concentric close structure, magnified.
5. Smaller spicula from the same region, magnified.
6. Spicula with spinuled limbs, magnified.
7. Spinules, magnified, of preceding fig. 6.
8. Contact spicula, with minute spinulose junctions, magnified.
9. The spicula just within the cortex, magnified.
10. Peltate cortex, dendritic, modified trifid spicula, magnified.

Plate XXV

Aphrocallistes sp.

Fig. 1. The specimen, natural size.
2. Large common derm-spicula, magnified.
3. Hexactinellids with long axis more or less ragged, magnified.
4, 5. Minute hexactinellids, magnified.
6. A multidentate scopuline, magnified.
7, 8. Brush-spicula, magnified.
9. Rosette, magnified.
10. An incomplete rosette, with a long axial fibre, magnified.
11. Rosettes, trifid, magnified.

Fig. 12. Attenuate straight-limbed, knobbed, simple rosette, magnified.
13. A spinulose hexactinellid spicule with knob, magnified.
14. An hexactinellid with serrate limbs, magnified.
15. An hexactinellid with prolonged axis, magnified.
16. A long, attenuate serrate fibre, magnified.
17. Plain processes of the skeleton, magnified.
18. Clubbed cylindrical spined processes, magnified.
19. The lattice-work at the free edge, magnified.
20. The lattice-work of the base, magnified.

On Individual Variation in the Branchial Sac of Simple Ascidians.

By W. A. Herdman, D.Sc., F.L.S., F.R.S.E.

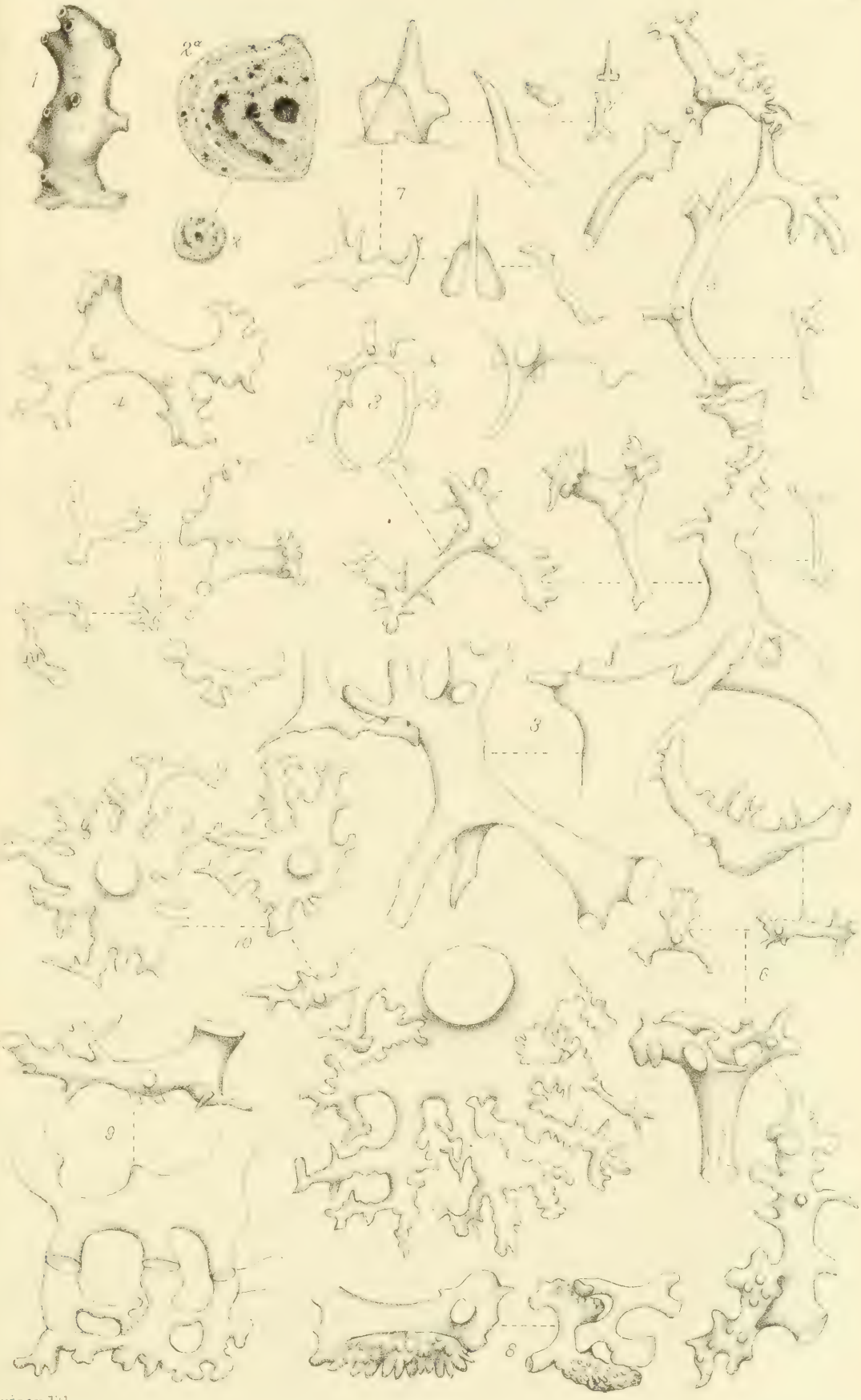
[Read April 21, 1881.]

The difficulty of determining the value of specific characters in Ascidians is well known to all who have worked at the group. It is now universally admitted that the old method of describing merely the external appearance of the animal is insufficient; as in many cases it is impossible, from an examination of the external characters alone, to determine the genus, and even in some cases the family, to which the specimen belongs. Consequently, most writers on the Tunicata in recent years have described in more or less detail certain internal characters, including the branchial sac and its related organs, the circlet of tentacles, the dorsal lamina, and the olfactory tubercle. The conditions of these important structures furnish most valuable generic and specific characters, and an account of them should undoubtedly form part of the description of an Ascidian.

It must not be forgotten, however, that some of these characters, in many species, vary considerably according to the individual; or, in other words, not only do varieties exist, but most individuals differ slightly from each other in points which are given as specific characters: this, of course, is only in certain species. Hence when the number of specimens for comparison is small, it is often a delicate matter to determine what is a good species.

My attention was first directed to this variation by reading Lacaze-Duthiers's description, in his great work on the Molgulidæ *, of three marked varieties of branchial sac in *Ctenicella Lanceplaini*, L.-Duth. This appears, however, from the account given, to be a

* H. de Lacaze-Duthiers, "Histoire des Ascidies simples des côtes de France," 2e partie, 'Archives de Zoologie expérimentale et générale,' t. vi. p. 619, pl. xxiii. figs. 9, 10, 11 (1877).



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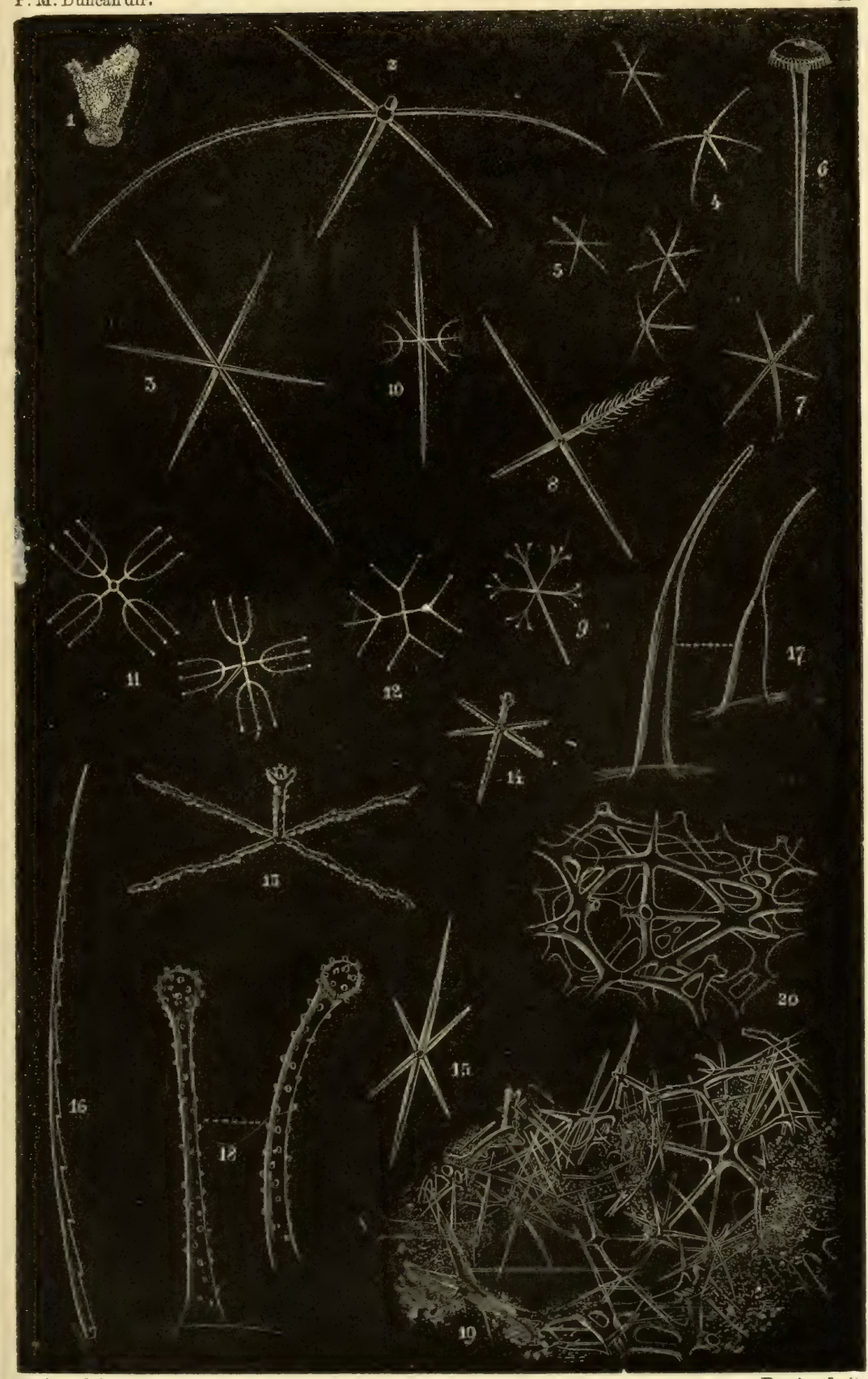
LITHISTID SPONGE & SPICULA.



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APHROCALLISTES SPECIES? AND SPICULA.